

## Gunter, Jason

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**From:** Nations, Mark <mnations@doerun.com>  
**Sent:** Monday, August 11, 2014 12:48 PM  
**To:** Gunter, Jason  
**Cc:** Yingling, Mark; James, Kevin; Neaville, Chris; Montgomery, Michael; robert.hinkson@dnr.mo.gov; brandon.wiles@dnr.mo.gov; Ty Morris (TMorris@barr.com); Hedrick, Samantha K.  
**Subject:** OLB Air Monitoring  
**Attachments:** Remediation\_Air\_Report\_-\_June\_2014[1].pdf; 2nd\_Qtr\_2014\_PM10\_Lead\_Meteorological\_Performance\_Audit\_Report[1].pdf

Jason,  
Attached is the data for June and 2<sup>nd</sup> quarter air results.  
Mark

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# **Monthly Ambient Air Monitoring Report**

The Doe Run Company  
Old Lead Belt Sites:  
Federal, Rivermines, National, and Leadwood

**June-2014**



SUITE 300  
1801 PARK 270 DRIVE  
ST. LOUIS, MO 63146

## Federal Site

Sample Results for **June-2014**

	St. Joe (Ballfields)		Big River#4		Water Treatment Plant	
Sample Date	TSP ug/m3	Lead ug/m3	TSP ug/m3	Lead ug/m3	TSP ug/m3	Lead ug/m3
6/2/14	21	0.021	19	0.014	20	0.007
6/3/14	25	0.014	27	0.021	31	0.028
6/4/14	22	0.007	24	0.007	29	0.007
6/5/14	23	0.007	18	0.007	22	0.007
6/6/14	26	0.007	30	0.020	34	0.007
6/9/14	13	0.007	15	0.007	13	0.007
6/10/14	22	0.014	14	0.007	14	0.007
6/11/14	24	0.042	20	0.020	23	0.077
6/12/14	21	0.007	38	0.048	21	0.021
6/13/14	18	0.007	30	0.014	25	0.007
6/16/14	49	0.014	38	0.007	41	0.007
6/17/14	58	0.014	47	0.007	52	0.007
6/18/14	46	0.021	37	0.007	47	0.014
6/19/14	33	0.014	25	0.007	28	0.014
6/20/14	34	0.014	34	0.014	38	0.014
6/23/14	18	0.007	19	0.007	22	0.000
6/24/14	30	0.028	24	0.007	22	0.014
6/25/14	23	0.007	32	0.021	22	0.014
6/26/14	22	0.007	18	0.007	24	0.000
6/27/14	22	0.007	16	0.007	21	0.007
6/30/14	91	0.021	96	0.028	14	0.000

Monthly Avg. TSP	31	30	27
Monthly Avg. Pb	0.014	0.013	0.013
May-14	0.038	0.018	0.024
Apr-14	0.025	0.011	0.023
<b>Rolling 3-Month</b>	<b>0.026</b>	<b>0.014</b>	<b>0.020</b>

Three month rolling average must be less than 0.15 ug/m3

### NOTES:

	Big River QA	
Sample Date	TSP ug/m3	Lead ug/m3
6/3/14	34	0.021
6/5/14	21	0.007
6/10/14	18	0.007
6/13/14	39	0.048
6/17/14	49	0.007
6/19/14	24	0.007
6/24/14	25	0.007
6/26/14	21	0.007

## Rivermines

Sample Results for **June-2014**

Sample Date	Big River #4		Rivermines South #1		Rivermines North #2		Rivermines East #3	
	TSP ug/m3	Lead ug/m3	TSP ug/m3	Lead ug/m3	TSP ug/m3	Lead ug/m3	TSP ug/m3	Lead ug/m3
6/2/14	19	0.014	17	0.007	26	0.105	20	0.007
6/3/14	27	0.021	30	0.042	22	0.021	31	0.028
6/4/14	24	0.007	14	0.007	26	0.035	29	0.007
6/5/14	18	0.007	21	0.008	18	0.007	22	0.007
6/6/14	30	0.020	invalid	invalid	25	0.007	34	0.007
6/9/14	15	0.007	invalid	invalid	14	0.007	13	0.007
6/10/14	14	0.007	invalid	invalid	12	0.007	14	0.007
6/11/14	20	0.020	invalid	invalid	11	0.014	23	0.077
6/12/14	38	0.048	38	0.140	16	0.007	21	0.021
6/13/14	30	0.014	33	0.117	21	0.007	25	0.007
6/16/14	38	0.007	41	0.007	54	0.177	41	0.007
6/17/14	47	0.007	45	0.007	54	0.170	52	0.007
6/18/14	37	0.007	36	0.007	50	0.178	47	0.014
6/19/14	25	0.007	26	0.007	36	0.127	28	0.014
6/20/14	34	0.014	30	0.014	26	0.007	38	0.014
6/23/14	19	0.007	invalid	invalid	20	0.021	22	0.000
6/24/14	24	0.007	invalid	invalid	14	0.000	22	0.014
6/25/14	32	0.021	31	0.028	23	0.014	22	0.014
6/26/14	18	0.007	22	0.007	21	0.007	24	0.000
6/27/14	16	0.007	invalid	invalid	17	0.028	21	0.007
6/30/14	96	0.028	83	0.014	88	0.050	14	0.000

Monthly Avg. TSP	30	33	28	27
Monthly Avg. Pb	0.013	0.029	0.047	0.013
May-14	0.018	0.027	0.052	0.024
Apr-14	0.011	0.077	0.023	0.023
<b>Rolling 3-Month</b>	<b>0.014</b>	<b>0.044</b>	<b>0.041</b>	<b>0.020</b>

Three month rolling average must be less than 0.15 ug/m3

**NOTES:**

6/5 thru 6/11, 6/23 and 6/24, Rivermines South: power failure  
6/27, Rivermines South: >25hr run time

Sample Date	Big River QA	
	TSP ug/m3	Lead ug/m3
6/3/14	34	0.021
6/5/14	21	0.007
6/10/14	18	0.007
6/13/14	39	0.048
6/17/14	49	0.007
6/19/14	24	0.007
6/24/14	25	0.007
6/26/14	21	0.007



# National Site

Sample Results for **June-2014**

	Big River #4		Ozark #1		Soccer Park #2		Water Treatment Plant	
Sample Date	TSP ug/m3	Lead ug/m3	TSP ug/m3	Lead ug/m3	TSP ug/m3	Lead ug/m3	TSP ug/m3	Lead ug/m3
6/2/14	19	0.014	22	0.007	19	0.014	20	0.007
6/3/14	27	0.021	29	0.007	29	0.014	31	0.028
6/4/14	24	0.007	24	0.007	26	0.007	29	0.007
6/5/14	18	0.007	21	0.007	23	0.007	22	0.007
6/6/14	30	0.020	32	0.007	27	0.007	34	0.007
6/9/14	15	0.007	15	0.000	18	0.007	13	0.007
6/10/14	14	0.007	19	0.007	14	0.007	14	0.007
6/11/14	20	0.020	16	0.014	17	0.007	23	0.077
6/12/14	38	0.048	22	0.007	22	0.007	21	0.021
6/13/14	30	0.014	17	0.007	17	0.007	25	0.007
6/16/14	38	0.007	44	0.014	48	0.014	41	0.007
6/17/14	47	0.007	52	0.014	invalid	invalid	52	0.007
6/18/14	37	0.007	39	0.021	30	0.007	47	0.014
6/19/14	25	0.007	32	0.014	33	0.014	28	0.014
6/20/14	34	0.014	31	0.007	31	0.007	38	0.014
6/23/14	19	0.007	21	0.000	21	0.007	22	0.000
6/24/14	24	0.007	26	0.007	24	0.007	22	0.014
6/25/14	32	0.021	29	0.007	25	0.014	22	0.014
6/26/14	18	0.007	28	0.007	24	0.014	24	0.000
6/27/14	16	0.007	19	0.007	23	0.014	21	0.007
6/30/14	96	0.028	93	0.007	94	0.021	14	0.000

Monthly Avg. TSP	30	30	28	27
Monthly Avg. Pb	0.013	0.008	0.010	0.013
May-14	0.018	0.013	0.020	0.024
Apr-14	0.011	0.010	0.013	0.023
<b>Rolling 3-Month</b>	<b>0.014</b>	<b>0.011</b>	<b>0.014</b>	<b>0.020</b>

Three month rolling average must be less than 0.15 ug/m3

## NOTES:

6/17, National #2: timer malfunction

	Big River QA	
Sample Date	TSP ug/m3	Lead ug/m3
6/3/14	34	0.021
6/5/14	21	0.007
6/10/14	18	0.007
6/13/14	39	0.048
6/17/14	49	0.007
6/19/14	24	0.007
6/24/14	25	0.007
6/26/14	21	0.007

## Leadwood

Sample Results for **June-2014**

	Big River #4		Leadwood South #1		Leadwood East #2		Leadwood North #3	
Sample Date	TSP ug/m3	Lead ug/m3	TSP ug/m3	Lead ug/m3	TSP ug/m3	Lead ug/m3	TSP ug/m3	Lead ug/m3
6/2/14	19	0.014	39	0.007	14	0.000	14	0.000
6/3/14	27	0.021	43	0.007	27	0.021	21	0.007
6/4/14	24	0.007	24	0.007	24	0.014	invalid	invalid
6/5/14	18	0.007	24	0.014	20	0.007	18	0.000
6/6/14	30	0.020	31	0.014	28	0.007	19	0.007
6/9/14	15	0.007	16	0.007	invalid	invalid	20	0.007
6/10/14	14	0.007	12	0.007	13	0.007	11	0.007
6/11/14	20	0.020	14	0.007	11	0.000	14	0.000
6/12/14	38	0.048	13	0.007	13	0.007	12	0.007
6/13/14	30	0.014	36	0.007	invalid	invalid	27	0.007
6/16/14	38	0.007	50	0.007	56	0.028	41	0.000
6/17/14	47	0.007	63	0.007	80	0.055	79	0.007
6/18/14	37	0.007	71	0.014	73	0.041	39	0.000
6/19/14	25	0.007	64	0.021	35	0.035	21	0.007
6/20/14	34	0.014	112	0.034	26	0.014	26	0.007
6/23/14	19	0.007	27	0.007	31	0.014	25	0.000
6/24/14	24	0.007	26	0.007	21	0.000	19	0.000
6/25/14	32	0.021	46	0.014	27	0.007	17	0.007
6/26/14	18	0.007	30	0.007	37	0.028	22	0.000
6/27/14	16	0.007	20	0.000	21	0.007	17	0.000
6/30/14	96	0.028	90	0.007	89	0.014	88	0.007

Monthly Avg. TSP	30	40	34	28
Monthly Avg. Pb	0.013	0.010	0.016	0.004
May-14	0.018	0.014	0.009	0.004
Apr-14	0.011	0.013	0.007	0.004
<b>Rolling 3-Month</b>	<b>0.014</b>	<b>0.012</b>	<b>0.011</b>	<b>0.004</b>

Three month rolling average must be less than 0.15 ug/m3

### NOTES:

6/4, Leadwood #3: <23hr run time  
6/9, Leadwood #2: <23hr run time  
6/13, Leadwood #2: > 24hr run time

	Big River QA	
Sample Date	TSP ug/m3	Lead ug/m3
6/3/14	34	0.021
6/5/14	21	0.007
6/10/14	18	0.007
6/13/14	39	0.048
6/17/14	49	0.007
6/19/14	24	0.007
6/24/14	25	0.007
6/26/14	21	0.007

## Federal Site

Sample Results for **June-2014**

Sample Date	St. Joe (Ballfields) <b>PM10</b> (ug/m3)	Big River#4 <b>PM10</b> (ug/m3)	Water Treatment <b>PM10</b> (ug/m3)
6/1/14	23	18	20
6/4/14	26	23	23
6/7/14	23	19	24
6/10/14	18	17	8
6/13/14	19	20	19
6/16/14	39	35	38
6/19/14	24	20	29
6/22/14	23	18	22
6/25/14	21	21	22
6/28/14	17	19	20

*Compliance with NAAQS is less than 150 ug/m3*

<b>Monthly Avg. PM10</b>	23	21	23
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**NOTES:**

Sample Date	Big River QA <b>PM10</b> (ug/m3)
6/4/14	26
6/10/14	10
6/16/14	19
6/22/14	16
6/28/14	16

## Rivermines

Sample Results for **June-2014**

	Big River #4	Rivermines South #1	Rivermines North #2	Rivermines East #3
Sample Date	<b>PM10</b> (ug/m3)	<b>PM10</b> (ug/m3)	<b>PM10</b> (ug/m3)	<b>PM10</b> (ug/m3)
6/1/14	18	16	19	20
6/4/14	23	13	19	23
6/7/14	19	invalid	21	24
6/10/14	17	invalid	11	8
6/13/14	20	28	11	19
6/16/14	35	40	38	38
6/19/14	20	23	29	29
6/22/14	18	22	20	22
6/25/14	21	20	20	22
6/28/14	19	23	16	20

*Compliance with NAAQS is less than 150 ug/m3*

<b>Monthly Avg. PM10</b>	21	23	20	23
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**NOTES:** 6/7,6/10, Rivermines South #1: power failure

	Big River QA
Sample Date	<b>PM10</b> (ug/m3)
6/4/14	26
6/10/14	10
6/16/14	19
6/22/14	16
6/28/14	16

## National Site

Sample Results for **June-2014**

Sample Date	Big River #4 PM10 (ug/m3)	Ozark #1 PM10 (ug/m3)	Soccer Park #2 PM10 (ug/m3)	Water Treatment PM10 (ug/m3)
6/1/14	18	19	20	20
6/4/14	23	23	24	23
6/7/14	19	24	24	24
6/10/14	17	19	14	8
6/13/14	20	14	17	19
6/16/14	35	38	37	38
6/19/14	20	24	24	29
6/22/14	18	21	12	22
6/25/14	21	17	17	22
6/28/14	19	invalid	14	20

Compliance with NAAQS is less than 150 ug/m3

<b>Monthly Avg. PM10</b>	21	22	20	23
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**NOTES:** 6/28, Ozark #1: <23hr run time.

Sample Date	Big River QA PM10 (ug/m3)
6/4/14	26
6/10/14	10
6/16/14	19
6/22/14	16
6/28/14	16

## Leadwood

Sample Results for **June-2014**

	Big River #4	Leadwood South #1	Leadwood East #2	Leadwood North #3
Sample Date	PM10 (ug/m3)	PM10 (ug/m3)	PM10 (ug/m3)	PM10 (ug/m3)
6/1/14	18	22	19	17
6/4/14	23	17	20	19
6/7/14	19	15	20	20
6/10/14	17	invalid	15	6
6/13/14	20	14	17	5
6/16/14	35	33	47	40
6/19/14	20	25	25	23
6/22/14	18	21	18	20
6/25/14	21	22	21	21
6/28/14	19	14	18	14

Compliance with NAAQS is less than 150 ug/m3

<b>Monthly Avg. PM10</b>	21	20	22	18
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**NOTES:** 6/10, Leadwood South #1: >25hr run time

	Big River QA
Sample Date	PM10 (ug/m3)
6/4/14	26
6/10/14	10
6/16/14	19
6/22/14	16
6/28/14	16

# Meterological Data - Old Lead Belt

## Jun-2014

24hr average

Date	Wind Speed (MPH)	Wind Direction	Sigma-Theta	Temperature (C)	Air Pressure (mmHg)	Rain (Inches)	Power Supply (Volts)
01-Jun-14	4.811	188.5	24.55	24.41	745	0.01	13.19
02-Jun-14	5.567	210.1	23.59	24.66	744	0	13.19
03-Jun-14	2.875	216.1	33.19	26.6	743	0	13.15
04-Jun-14	4.342	221.2	28.73	24.7	740	0.36	13.18
05-Jun-14	2.518	57.47	32.57	19.64	742	0.01	13.26
06-Jun-14	1.71	67.99	36.13	21.96	743	0	13.22
07-Jun-14	3.729	201	33.97	21.37	741	0.24	13.24
08-Jun-14	3.081	348.5	31.24	20.52	744	0.01	13.23
09-Jun-14	3.205	97.9	31.09	19.81	740	0.97	13.24
10-Jun-14	2.686	180	29.61	20.32	737	0.21	13.18
11-Jun-14	2.393	287	34.97	20.59	739	0	13.23
12-Jun-14	1.826	277.8	34.33	19.88	742	0.05	13.24
13-Jun-14	3.484	348.4	25.91	19.07	744	0	13.23
14-Jun-14	3.612	172.1	27.22	18.49	745	0	13.26
15-Jun-14	5.048	188.7	23.6	23.39	743	0.02	13.23
16-Jun-14	5.558	195.9	23.21	27.2	745	0	13.16
17-Jun-14	7.1	204.6	23.95	28.08	744	0	13.13
18-Jun-14	5.483	205.4	25	28.41	744	0	13.13
19-Jun-14	3.837	206	23.67	27.64	745	0	13.14
20-Jun-14	2.021	244.5	39.75	27.32	745	0.35	13.14
21-Jun-14	2.437	242	39.83	25.44	744	0.22	13.16
22-Jun-14	2.144	202.3	36.39	22.55	741	0.56	13.21
23-Jun-14	1.953	204	37.03	23.49	741	1.01	13.18
24-Jun-14	3.055	312.7	28.03	23.79	743	0.75	13.19
25-Jun-14	1.491	250.8	35.58	25.03	745	0	13.18
26-Jun-14	3.467	181.4	27.82	24.81	745	0	13.17
27-Jun-14	4.514	175.7	26.99	24.01	744	0	13.19
28-Jun-14	6.595	191.1	24.4	25.64	744	0	13.18
29-Jun-14	5.71	197.8	24.16	23.46	745	0.22	13.2
30-Jun-14	5.44	205.7	25.81	27.89	741	0	13.15

May 30, 2014

Ms. Genevieve Bodnar  
Senior Environmental Engineer  
The Doe Run Company  
SEMO Division

RE: 2nd Quarter 2014 Lead/PM10 Samplers and Meteorological System  
Performance Audit Report.

Dear Ms. Bodnar,


Please find enclosed the worksheets detailing the Lead/PM10 sampler's multi-point and one-point flow verifications, and meteorological sensors accuracy checks that were recently performed on the Doe Run Park Hills Monitoring Network. A copy of the current certifications for the audit devices that was used has also been enclosed.

All of the verifications and checks were found to be within expected guidelines.

We had agreed that the wind monitor at the Big River site would be replaced since the existing unit was in need of repair. A new wind monitor was installed and its accuracy was verified to be correct.

After reviewing the enclosed information, please feel free to call with any comments or questions. Thank you for your business.

Sincerely,



John A. Kunkel  
Inquest Environmental, Inc.



## **PM10 Sampler Verifications**

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Big River	Intercept (Qa)	-0.00227
Sampler	#4 Primary PM10	Temperature	23.2 °C 296.4 °K
Flow Controller	P1019	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.80	1.177	28.50	53.23	0.930	1.135	-3.57	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.40	54.91	0.928	1.133	1.173	3.81	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.75	1.169	29.40	54.91	0.928	1.133	-3.08	± 4%
3.80	1.177	28.50	53.23	0.930	1.135	-3.57	± 4%
3.85	1.184	27.40	51.17	0.933	1.139	-3.80	± 4%
3.90	1.192	25.90	48.37	0.937	1.144	-4.03	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Big River	Intercept (Qa)	-0.00227
Sampler	#4 QA PM10	Temperature	23.2 °C 296.4 °K
Flow Controller	P2952	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.70	1.161	27.70	51.73	0.932	1.125	-3.10	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.10	54.35	0.929	1.121	1.156	2.30	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.60	1.145	28.40	53.04	0.930	1.122	-2.01	± 4%
3.65	1.153	28.00	52.29	0.931	1.123	-2.60	± 4%
3.70	1.161	27.70	51.73	0.932	1.125	-3.10	± 4%
3.75	1.169	27.00	50.43	0.934	1.127	-3.59	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (South)	Intercept (Qa)	-0.00227
Sampler	#1 PM10	Temperature	30.0 °C 303.2 °K
Flow Controller	P1500	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.70	1.174	28.40	53.04	0.930	1.145	-2.47	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.00	54.16	0.929	1.144	1.172	3.72	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.65	1.166	29.10	54.35	0.929	1.144	-1.89	± 4%
3.70	1.174	28.40	53.04	0.930	1.145	-2.47	± 4%
3.75	1.182	26.50	49.49	0.935	1.152	-2.54	± 4%
3.80	1.190	25.50	47.63	0.938	1.156	-2.86	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (School)	Intercept (Qa)	-0.00227
Sampler	#2 PM10	Temperature	27.0 °C 300.2 °K
Flow Controller	P6071	Station Pressure	30.04 "Hg 763.0 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.75	1.176	29.30	54.72	0.928	1.151	-2.13	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.20	54.54	0.929	1.152	1.176	4.07	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.70	1.168	30.00	56.03	0.927	1.150	-1.54	± 4%
3.75	1.176	29.30	54.72	0.928	1.151	-2.13	± 4%
3.80	1.184	28.00	52.29	0.931	1.154	-2.53	± 4%
3.85	1.191	26.70	49.87	0.935	1.159	-2.69	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (Mill St)	Intercept (Qa)	-0.00227
Sampler	#3 PM10	Temperature	29.0 °C 302.2 °K
Flow Controller	P1018	Station Pressure	30.03 "Hg 762.8 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.80	1.188	28.80	53.79	0.929	1.146	-3.54	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
28.70	53.60	0.930	1.147	1.188	5.13	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.75	1.180	29.50	55.10	0.928	1.145	-2.97	± 4%
3.80	1.188	28.80	53.79	0.929	1.146	-3.54	± 4%
3.85	1.195	25.80	48.19	0.937	1.156	-3.26	± 4%
3.90	1.203	22.80	42.58	0.944	1.165	-3.16	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

#### Calculations:

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Rivermines (Quarry)	Intercept (Qa)	-0.00227
Sampler	#1 PM10	Temperature	26.4 °C 299.6 °K
Flow Controller	P4601	Station Pressure	29.98 "Hg 761.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.50	1.136	28.90	53.98	0.929	1.098	-3.35	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.10	54.35	0.929	1.098	1.135	0.44	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.40	1.120	29.50	55.10	0.928	1.097	-2.05	± 4%
3.50	1.136	28.90	53.98	0.929	1.098	-3.35	± 4%
3.55	1.144	27.30	50.99	0.933	1.102	-3.67	± 4%
3.60	1.152	26.10	48.75	0.936	1.106	-3.99	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Rivermines (Wood St)	Intercept (Qa)	-0.00227
Sampler	#2 PM10	Temperature	26.4 °C 299.6 °K
Flow Controller	P4507	Station Pressure	29.98 "Hg 761.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.45	1.128	28.30	52.85	0.931	1.120	-0.71	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.00	54.16	0.929	1.118	1.126	-0.35	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.40	1.120	29.50	55.10	0.928	1.117	-0.27	± 4%
3.45	1.128	28.30	52.85	0.931	1.120	-0.71	± 4%
3.50	1.136	27.40	51.17	0.933	1.123	-1.14	± 4%
3.55	1.144	26.50	49.49	0.935	1.125	-1.66	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

#### Calculations:

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100



Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Rivermines (Wtr Plnt)	Intercept (Qa)	-0.00227
Sampler	#3 PM10	Temperature	30.5 °C 303.7 °K
Flow Controller	P2951	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.65	1.167	28.30	52.85	0.931	1.135	-2.74	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.40	54.91	0.928	1.131	1.162	2.83	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.60	1.159	29.60	55.28	0.928	1.131	-2.42	± 4%
3.65	1.167	28.30	52.85	0.931	1.135	-2.74	± 4%
3.70	1.175	27.40	51.17	0.933	1.137	-3.23	± 4%
3.75	1.183	26.00	48.56	0.936	1.138	-3.80	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

#### Calculations:

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Ozark Insulation	Intercept (Qa)	-0.00227
Sampler	#1 PM10	Temperature	30.0 °C 303.2 °K
Flow Controller	P2950	Station Pressure	29.98 "Hg 761.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.65	1.167	28.40	53.04	0.930	1.130	-3.17	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
28.00	52.29	0.931	1.131	1.167	3.27	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.60	1.159	29.50	55.10	0.928	1.128	-2.67	± 4%
3.65	1.167	28.40	53.04	0.930	1.130	-3.17	± 4%
3.70	1.175	27.00	50.43	0.934	1.135	-3.40	± 4%
3.75	1.183	26.10	48.75	0.936	1.138	-3.80	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Hanley Park	Intercept (Qa)	-0.00227
Sampler	#2 PM10	Temperature	30.5 °C    303.7 °K
Flow Controller	P2949	Station Pressure	30.00 "Hg    762.0 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.60	1.160	28.00	52.29	0.931	1.128	-2.76	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.30	54.72	0.928	1.125	1.156	2.30	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.50	1.143	29.40	54.91	0.928	1.125	-1.57	± 4%
3.60	1.160	28.00	52.29	0.931	1.128	-2.76	± 4%
3.65	1.168	27.20	50.80	0.933	1.131	-3.17	± 4%
3.70	1.176	26.40	49.31	0.935	1.133	-3.66	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	St Joe Park	Intercept (Qa)	-0.00227
Sampler	#4 PM10	Temperature	30.5 °C    303.7 °K
Flow Controller	P4353	Station Pressure	30.02 "Hg    762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.50	1.143	29.00	54.16	0.929	1.120	-2.01	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
28.50	53.23	0.930	1.121	1.144	1.24	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.45	1.135	30.60	57.15	0.925	1.116	-1.67	± 4%
3.50	1.143	29.00	54.16	0.929	1.120	-2.01	± 4%
3.60	1.159	28.10	52.48	0.931	1.122	-3.19	± 4%
3.65	1.167	27.40	51.17	0.933	1.125	-3.60	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

## **Lead/TSP Sampler Verifications**

Date	May 13, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Big River	Intercept (Qa)	-0.00227
Sampler	#4 Primary TSP	Temperature	13.9 °C 287.1 °K
Flow Controller	P4557	Station Pressure	30.11 "Hg 764.8 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.90	1.171	20.90	39.05	0.949	1.222	4.36	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
20.80	38.86	0.949	1.222	1.169	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.80	1.156	24.20	45.21	0.941	1.211	4.76	± 5%
3.85	1.164	22.00	41.10	0.946	1.218	4.64	± 5%
3.90	1.171	20.90	39.05	0.949	1.222	4.36	± 5%
3.95	1.179	19.20	35.87	0.953	1.228	4.16	± 5%
4.00	1.186	17.00	31.76	0.958	1.234	4.05	± 5%

**Calculations:**

Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 13, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Big River #4	Intercept (Qa)	-0.00227
Sampler	QA TSP	Temperature	13.9 °C 287.1 °K
Flow Controller	P4558	Station Pressure	30.11 "Hg 764.8 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.05	1.194	20.10	37.55	0.951	1.220	2.18	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
20.20	37.74	0.951	1.220	1.193	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.90	1.171	22.90	42.78	0.944	1.211	3.42	± 5%
4.00	1.186	21.10	39.42	0.948	1.216	2.53	± 5%
4.05	1.194	20.10	37.55	0.951	1.220	2.18	± 5%
4.10	1.201	19.30	36.06	0.953	1.223	1.83	± 5%
4.20	1.215	18.40	34.38	0.955	1.226	0.91	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (South)	Intercept (Qa)	-0.00227
Sampler	#1 TSP	Temperature	30.0 °C    303.2 °K
Flow Controller	P4559	Station Pressure	30.02 "Hg    762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.50	1.295	26.80	50.07	0.934	1.237	-4.48	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
27.00	50.44	0.934	1.237	1.292	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.266	28.40	53.06	0.930	1.232	-2.69	± 5%
4.40	1.280	27.50	51.38	0.933	1.236	-3.44	± 5%
4.50	1.295	26.80	50.07	0.934	1.237	-4.48	± 5%
4.60	1.309	24.80	46.33	0.939	1.244	-4.97	± 5%
4.65	1.316	22.00	41.10	0.946	1.254	-4.71	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)



Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (School)	Intercept (Qa)	-0.00227
Sampler	#2 TSP	Temperature	27.0 °C 300.2 °K
Flow Controller	P6793	Station Pressure	30.04 "Hg 763.0 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.40	1.273	26.60	49.70	0.935	1.216	-4.48	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
26.00	48.58	0.936	1.217	1.271	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.259	28.70	53.62	0.930	1.209	-3.97	± 5%
4.35	1.266	27.80	51.94	0.932	1.212	-4.27	± 5%
4.40	1.273	26.60	49.70	0.935	1.216	-4.48	± 5%
4.45	1.281	24.60	45.96	0.940	1.223	-4.53	± 5%
4.55	1.295	22.10	41.29	0.946	1.231	-4.94	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (Mill St)	Intercept (Qa)	-0.00227
Sampler	#3 TSP	Temperature	29.0 °C 302.2 °K
Flow Controller	P4476	Station Pressure	30.03 "Hg 762.8 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.50	1.292	23.40	43.72	0.943	1.233	-4.57	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
23.90	44.65	0.941	1.230	1.286	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.35	1.271	26.80	50.07	0.934	1.221	-3.93	± 5%
4.40	1.278	24.60	45.96	0.940	1.229	-3.83	± 5%
4.50	1.292	23.40	43.72	0.943	1.233	-4.57	± 5%
4.55	1.299	21.70	40.54	0.947	1.239	-4.62	± 5%
4.60	1.307	19.20	35.87	0.953	1.247	-4.59	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Rivermines (Quarry)	Intercept (Qa)	-0.00227
Sampler	#1 TSP	Temperature	26.4 °C 299.6 °K
Flow Controller	P2940	Station Pressure	29.98 "Hg 761.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.259	27.20	50.82	0.933	1.216	-3.42	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
27.00	50.44	0.934	1.218	1.260	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.20	1.244	28.70	53.62	0.930	1.212	-2.57	± 5%
4.25	1.252	28.10	52.50	0.931	1.213	-3.12	± 5%
4.30	1.259	27.20	50.82	0.933	1.216	-3.42	± 5%
4.35	1.266	25.80	48.20	0.937	1.222	-3.48	± 5%
4.45	1.281	24.10	45.03	0.941	1.227	-4.22	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Rivermines Wood St	Intercept (Qa)	-0.00227
Sampler	#2 TSP	Temperature	26.4 °C 299.6 °K
Flow Controller	P2941	Station Pressure	29.98 "Hg 761.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.20	1.244	26.50	49.51	0.935	1.221	-1.85	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
26.20	48.95	0.936	1.222	1.245	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.00	1.214	28.60	53.43	0.930	1.214	0.00	± 5%
4.10	1.229	27.90	52.13	0.932	1.217	-0.98	± 5%
4.20	1.244	26.50	49.51	0.935	1.221	-1.85	± 5%
4.25	1.252	25.00	46.71	0.939	1.226	-2.08	± 5%
4.35	1.266	23.90	44.65	0.941	1.229	-2.92	± 5%

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**Calculations:**

Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Rivermines Wtr Plnt	Intercept (Qa)	-0.00227
Sampler	#3 TSP	Temperature	30.5 °C 303.7 °K
Flow Controller	P4475	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.267	26.50	49.51	0.935	1.221	-3.63	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
26.20	48.95	0.936	1.222	1.266	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.25	1.259	28.10	52.50	0.931	1.216	-3.42	± 5%
4.35	1.274	27.40	51.19	0.933	1.218	-4.40	± 5%
4.30	1.267	26.50	49.51	0.935	1.221	-3.63	± 5%
4.40	1.281	25.10	46.89	0.939	1.227	-4.22	± 5%
4.45	1.289	23.00	42.97	0.944	1.233	-4.34	± 5%

**Calculations:**Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Ozark Insulation	Intercept (Qa)	-0.00227
Sampler	#1 TSP	Temperature	30.0 °C 303.2 °K
Flow Controller	P2939	Station Pressure	29.98 "Hg 761.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.40	1.281	25.50	47.64	0.937	1.232	-3.83	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
25.10	46.89	0.938	1.233	1.280	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.25	1.259	27.50	51.38	0.933	1.226	-2.62	± 5%
4.30	1.266	26.80	50.07	0.934	1.228	-3.00	± 5%
4.40	1.281	25.50	47.64	0.937	1.232	-3.83	± 5%
4.50	1.296	24.00	44.84	0.941	1.237	-4.55	± 5%
4.55	1.303	22.90	42.78	0.944	1.241	-4.76	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Hanley Park (Crane St.)	Intercept (Qa)	-0.00227
Sampler	#2 TSP	Temperature	30.5 °C 303.7 °K
Flow Controller	P4474	Station Pressure	30.00 "Hg 762.0 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.267	26.60	49.70	0.935	1.215	-4.10	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
26.50	49.51	0.935	1.215	1.265	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.10	1.237	28.70	53.62	0.930	1.208	-2.34	± 5%
4.20	1.252	27.50	51.38	0.933	1.212	-3.19	± 5%
4.30	1.267	26.60	49.70	0.935	1.215	-4.10	± 5%
4.35	1.274	24.80	46.33	0.939	1.220	-4.24	± 5%
4.40	1.282	23.00	42.97	0.944	1.227	-4.29	± 5%

**Calculations:**

Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	St Joe Park	Intercept (Qa)	-0.00227
Sampler	#4 TSP	Temperature	30.5 °C 303.7 °K
Flow Controller	P6792	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.267	25.70	48.02	0.937	1.227	-3.16	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
26.20	48.95	0.936	1.226	1.265	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.20	1.252	28.30	52.87	0.931	1.219	-2.64	± 5%
4.25	1.259	27.70	51.75	0.932	1.220	-3.10	± 5%
4.30	1.267	25.70	48.02	0.937	1.227	-3.16	± 5%
4.40	1.281	24.80	46.33	0.939	1.230	-3.98	± 5%
4.50	1.296	23.60	44.09	0.942	1.234	-4.78	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)



## **Calibration Orifice Certification Worksheet**



TISCH ENVIRONMENTAL, INC.  
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ORIFICE TRANSFER STANDARD CERTIFICATION WORKSHEET TE-5028A

Date - Jan 09, 2014 Rootmeter S/N 0438320 Ta (K) - 292  
 Operator Tisch Orifice I.D. - 1882 Pa (mm) - 759.46

PLATE OR VDC #	VOLUME START (m3)	VOLUME STOP (m3)	DIFF VOLUME (m3)	DIFF TIME (min)	METER DIFF Hg (mm)	ORFICE DIFF H2O (in.)
1	NA	NA	1.00	1.3530	4.1	1.50
2	NA	NA	1.00	1.0430	6.8	2.50
3	NA	NA	1.00	0.9510	8.1	3.00
4	NA	NA	1.00	0.8790	9.5	3.50
5	NA	NA	1.00	0.6660	16.3	6.00

DATA TABULATION

Vstd	(x axis) Qstd	(y axis)		Va	(x axis) Qa	(y axis)
1.0143	0.7496	1.2368		0.9945	0.7350	0.7594
1.0106	0.9690	1.5967		0.9910	0.9501	0.9804
1.0089	1.0608	1.7491		0.9893	1.0402	1.0740
1.0070	1.1456	1.8893		0.9874	1.1233	1.1600
0.9978	1.4983	2.4736		0.9784	1.4691	1.5188
Qstd slope (m) = 1.65282				Qa slope (m) = 1.03497		
intercept (b) = -0.00370				intercept (b) = -0.00227		
coefficient (r) = 0.99999				coefficient (r) = 0.99999		
y axis = SQRT[H2O(Pa/760) (298/Ta)]				y axis = SQRT[H2O(Ta/Pa)]		

CALCULATIONS

Vstd = Diff. Vol [(Pa-Diff. Hg)/760] (298/Ta)  
 Qstd = Vstd/Time

Va = Diff Vol [(Pa-Diff Hg)/Pa]  
 Qa = Va/Time

For subsequent flow rate calculations:

Qstd = 1/m{ [SQRT(H2O(Pa/760) (298/Ta))] - b}  
 Qa = 1/m{ [SQRT H2O(Ta/Pa)] - b}

## **Meteorological Sensor's Accuracy Checks**

# Inquest Environmental, Inc.

## Wind Direction Sensor Performance Audit

Operator The Doe Run Co  
 Location Big River  
 Station Name Meteorological System  
 Technician J. Kunkel/R Jones

Date 05/13/2014  
 Start Time 09:00  
 Stop Time 12:30

Sensor Mfg RM Young  
 Sensor Model Wind Monitor AQ  
 Serial Number 128618  
 Sensor Height 10.0 Meters

Station Declination 0.0 Deg  
 Measured Angle 180.0 Deg  
 Corrected Angle 180.0 Deg  
 Alignment Error 0.0 Deg

Vane Angle	Data Logger	Results	
		Difference ± 3 Deg Limit	Total Error ± 5 Deg Limit
0/360	0.3	0.3	0.3
90	91.0	1.0	1.0
180	179.0	-1.0	-1.0
270	270.5	0.5	0.5

Average Difference (Degrees)	0.2
Average Total Error (Degrees)	0.2

Audit Device	Wind Vane Alignment	Direction
Type	Pocket Transit	Vane Angle Fixture
Mfg.	Brunton	R.M. Young
Model	5008	18212
Serial No.	5080304492	None

Comments: Wind direction was verified by determining the orientation of the sensor in respect to True North. This was measured using a tri-pod mounted transit aligned along the length of the sensor while locked from rotating. A magnetic declination of -0 degrees was used to determine True North. The linearity of the sensor was determined by aligning the sensor to an indexed test fixture provided by the manufacturer. The four cardinal directions were verified using the fixture. No adjustments were made to the sensor.

# Inquest Environmental, Inc.

## Wind Speed Audit

Operator The Doe Run Co  
Location Big River  
Station Name Meteorological System  
Auditor(s) J Kunkel/M. Kunkel

Date 05/13/2014  
Start Time 09:00  
Stop Time 12:30

Sensor Mfg RM Young  
Sensor Model Wind Monitor AQ  
Serial Number 128618  
Sensor Height 10.0 Meters

Audit Standard		DAS Response		Limit
RPM	MPH	MPH	Difference	MPH
Zero	0.00	0.00	0.00	0.45
500	5.70	5.70	0.00	0.74
1000	11.50	11.50	0.00	1.03
1500	17.20	17.20	0.00	1.31
2000	22.90	22.90	0.00	1.60
3000	34.40	34.50	0.10	2.17
6000	68.70	68.70	0.00	3.89
Average			0.02	

± (0.45 MPH + 5%)

Audit Device	Anemometer Drive
Type	Variable Speed
Mfg.	R.M. Young
Model	18801
Serial No.	CAO1631

Comments: Wind speed was verified using a variable speed anemometer drive. The propeller was removed from the sensor and the drive was connected using a flexible connector. The sensor was then rotated in the appropriate direction at several different speeds. Sensor responses were taken from the data logger. No adjustments were made to the sensor.

# Inquest Environmental, Inc.

## Barometric Pressure Sensor Performance Audit

Operator The Doe Run Co  
Location Big River  
Station Name Meteorological System  
Technician J Kunkel/M Kunkel

Date 05/13/2014  
Start Time 09:00  
Stop Time 12:30

Sensor Mfg Setra  
Sensor Model 276  
Serial Number 2626447

Audit Device	Data Logger Response	
	BP	Difference
mm HG	mm HG	mm HG
744.10	746.30	2.20

Note: Limit is +/- 7.5 mm HG.

Audit Device	
Type	Digital Barometer
Mfg.	AIR
Model	AIR-HB-1A
Serial No.	6G3745

Comments: The barometric pressure is verified by co-locating the sensor with a certified digital barometer. The verification was conducted at one level after allowing the sensor and calibration device ample time to stabilize.  
The sensor error was determined by comparing the sensor's data logger response to the display on the certified digital barometer. No adjustments were made to the sensor.

# Inquest Environmental, Inc.

## Temperature Sensor Performance Audit

Operator The Doe Run Co  
 Location Big River  
 Station Name Meteorological System  
 Technician J Kunkel/M Kunkel

Date 05/13/2014  
 Start Time 09:00  
 Stop Time 12:30

### Sensor Information

Sensor Mfg Climatronics  
 Sensor Model NA  
 Serial Number NA  
 Sensor Height 2 meters

Audit Device °C	Sensor	
	Data Logger °C	Difference °C
1.00	0.90	-0.10
16.20	16.30	0.10
45.30	45.10	-0.20
Average		-0.07

Note: The limit for each point is +/- 0.5 °C

Audit Device	
Type	Digital Thermometer
Mfg.	Control Company
Model	15-077-8
Serial No.	21357521

Comments: The temperature is verified by co-locating the sensor with a certified digital thermometer. The verification is conducted at three levels using two water baths (iced and hot water) and the ambient temperature. The sensor error was determined by comparing the sensor's data logger response to the display on the certified digital thermometer. No adjustments were made to the sensor.

# Inquest Environmental, Inc.

## Precipitation Gauge Performance Audit

Operator The Doe Run Co  
Location Big River  
Station Name Meteorological System  
Technician J Kunkel/M Kunkel

Date 05/13/2014  
Start Time 09:00  
Stop Time 12:30

Sensor Mfg Texas Electronics  
Sensor Model TR525I  
Serial Number 36611-805  
Diameter (inches) 6.00

Audit Device	Data Logger Response	
	Gauge Tips	Difference %
Known Tips		
98.00	93.00	-5.10

Note: Limit is +/- 10%.

Audit Device	
Type	Graduated Beaker
Mfg.	Texas Instruments
Model	FC-525
Serial No.	NA

Comments: The precipitation gauge output was verified using a field calibration kit  
supplied by the manufacturer. The kit consists of a graduated beaker  
and a calibration funnel using a precision orifice at the water outlet.  
Water was measured in the beaker and poured into the funnel while  
mounted on the gauge. The amount of precipitation recorded by the  
data logger was then compared to the known amount of water passing  
through the funnel. 100 tips equals one inch of rainfall. The gauge  
was cleaned and no adjustments were made.



## **Meteorological Audit Devices Certifications**



**CALIBRATION PROCEDURE**  
**18801/18810 ANEMOMETER DRIVE**

**DWG: CP18801(A)**

REV: C101107 PAGE: 2 of 3  
BY: TJT DATE: 10/11/07  
CHK: JC W.C. GAS-12

**CERTIFICATE OF CALIBRATION AND TESTING**

MODEL: **18801** (Comprised of Models 18820 Control Unit & 18830 Motor Assembly)  
SERIAL NUMBER: CA01631

R. M. Young Company certifies that the above equipment was inspected and calibrated prior to shipment in accordance with established manufacturing and testing procedures. Standards established by R.M. Young Company for calibrating the measuring and test equipment used in controlling product quality are traceable to the National Institute of Standards and Technology.

Nominal Motor Rpm	Output Frequency Hz (1)	Calculated Rpm (2)	Indicated Rpm (3)
600	320	600	600
1200	640	1200	1200
2400	1280	2400	2400
4200	2240	4200	4200
6,000	3200	6000	6000
8,100	4320	8100	8100
9,900	5280	9900	9900
<input checked="" type="checkbox"/> Clockwise and Counterclockwise rotation verified			

- (1) Measured at the optical encoder output.  
(2) Frequency output produces 32 pulses per revolution of motor shaft.  
(3) Indicated on the Control Unit LCD display.

\* Indicates out of tolerance

☒ No Calibration Adjustments Required ☐ As Found ☐ As Left

Traceable frequency meter used in calibration Model: DP5740 SN: 4683

Date of inspection 15 Nov 2013  
Inspection Interval One Year

Tested By EC



Calibration  
Certificate No. 1750.01

Calibration complies with ISO/IEC  
17025, ANSI/NCSL Z540-1, and 9001



Cert. No.: 4000-5654260

### Traceable® Certificate of Calibration for Digital Thermometer

Cust ID: Inquest Environmental Inc., 3609 Mojave Ct. Suite E, Attn. Mitchell Kunkel, Columbia, MO 65202 U.S.A. (RMA: 983601)

#### Instrument Identification:

Model Numbers: 15-077-8, FB50266, 245BY S/N: 21357521 Manufacturer: Control Company

Model: 15-077-7

S/N: 72415694

#### Standards/Equipment:

Description	Serial Number	Due Date	NIST Traceable Reference
Temperature Calibration Bath TC-179	A45240		
Thermistor Module	A17118	2/13/14	1000332071
Temperature Probe	128	2/20/14	6-B48Z9-30-1
Temperature Calibration Bath TC-218	A73332		
Thermistor Module	A27129	10/25/14	1000346002
Temperature Probe	5202	11/30/14	15-B15PW-1-1
Temperature Calibration Bath TC-275	B16388		
Digital Thermometer	B16815	8/12/14	1000341967
PRT Temperature Probe	02022	8/14/15	B3812004

#### Certificate Information:

Technician: 68

Procedure: CAL-06

Cal Date: 1/17/14

Cal Due: 1/17/15

Test Conditions: 24.5°C 32.0 %RH 1026 mBar

#### Calibration Data:

Unit(s)	Nominal	As Found	In Tol	Nominal	As Left	In Tol	Min	Max	±U	TUR
°C	0.000	0.006	Y	0.000	0.000	Y	-0.050	0.050	0.013	3.8:1
°C	25.003	25.003	Y	25.003	24.999	Y	24.953	25.053	0.023	2.2:1
°C	60.000	59.988	Y	60.000	60.002	Y	59.950	60.050	0.014	3.6:1
°C	99.998	99.961	Y	99.998	100.000	Y	99.948	100.048	0.018	2.8:1

This Instrument was calibrated using Instruments Traceable to National Institute of Standards and Technology.

A Test Uncertainty Ratio of at least 4:1 is maintained unless otherwise stated and is calculated using the expanded measurement uncertainty. Uncertainty evaluation includes the instrument under test and is calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement" (GUM). The uncertainty represents an expanded uncertainty using a coverage factor k=2 to approximate a 95% confidence level. In tolerance conditions are based on test results falling within specified limits with no reduction by the uncertainty of the measurement. The results contained herein relate only to the item calibrated. This certificate shall not be reproduced except in full, without written approval of Control Company.

Nominal=Standard's Reading; As Left=Instrument's Reading; In Tol=In Tolerance; Min/Max=Acceptance Range; ±U=Expanded Measurement Uncertainty; TUR=Test Uncertainty Ratio; Accuracy=±(Max-Min)/2; Min = As Left Nominal(Rounded) - Tolerance; Max = As Left Nominal(Rounded) + Tolerance; Date=MM/DD/YY

*Nicol Rodriguez*  
Nicol Rodriguez, Quality Manager

*Aaron Judice*  
Aaron Judice, Technical Manager

#### Maintaining Accuracy:

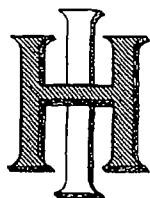
In our opinion once calibrated your Digital Thermometer should maintain its accuracy. There is no exact way to determine how long calibration will be maintained. Digital Thermometers change little, if any at all, but can be affected by aging, temperature, shock, and contamination.

#### Recalibration:

For factory calibration and re-certification traceable to National Institute of Standards and Technology contact Control Company.

CONTROL COMPANY 4455 Rex Road Friendswood, TX 77546 USA  
Phone 281 482-1714 Fax 281 482-9448 service@control3.com www.control3.com

Control Company is an ISO 17025:2005 Calibration Laboratory Accredited by (A2LA) American Association for Laboratory Accreditation, Certificate No. 1750.01.  
Control Company is ISO 9001:2008 Quality Certified by (DNV) Det Norske Veritas, Certificate No. CERT-01805-2006-AQ-HOU-RvA.  
International Laboratory Accreditation Cooperation (ILAC) - Multilateral Recognition Arrangement (MRA).



# HASS INSTRUMENT CORPORATION

6711 OLD BRANCH AVENUE • CAMP SPRINGS, MD 20748-6990 • (301) 449-5454 • FAX (301) 449-5455

## CALIBRATION

## REPORT

BAROMETER/ALTIMETER  
AIR Model AIR-HB-1A  
Serial No. 6G3745

TEST POINT	TEST <u>PRESSURE</u>	DIGITAL READOUT	READOUT ERROR	CORRECTION REQUIRED
1	930.00	931.9	+1.9	-1.9
2	970.00	971.9	+1.9	-1.9
3	1010.00	1012.0	+2.0	-2.0
4	1050.00	1051.9	+1.9	-1.9
5	1018.01	1019.9	+1.9	-1.9

### NOTES:

1. All data are in Millibars (hPa) and were taken at 75 F (24 C).
2. To correct the Digital Readout of the instrument, either algebraically add the CORRECTION REQUIRED to, or algebraically subtract the READOUT ERROR from, the readout shown on the instrument.
3. The TEST PRESSURE was generated using Type A-1 Barometer S/N 3327, and was approached in an increasing-pressure direction.
4. The TEST PRESSURE for TEST POINT 5 was ambient atmospheric pressure.
5. The BAROMETER/ALTIMETER was horizontal during the calibration.
6. The LCD screen of the BAROMETER/ALTIMETER has some trash in the center of the display, but it does not interfere with the readout.
7. Although the Digital Readout of the instrument can be adjusted to incorporate the average CORRECTION REQUIRED, this has not been done.

Calibration Date: 5 February 2014

(SEAL)

By: Bernard I. Hass

Bernard I. Hass

# BRUNTON OUTDOOR GROUP

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## CERTIFICATE OF CALIBRATION

### Equipment Owner

Name: Environmental Atten: Mitchell Kunkel  
Address: 3609 Mojave Court Ste E  
Columbia, MO 65202

Calibration traceable to the National Institute of Standards and Technology in accordance with MIL-STD-45662A has been accomplished on the instrument listed below by comparison with standards maintained by the Brunton Outdoor Group. The accuracy and stability of all standards maintained by the Brunton Outdoor Group are traceable to national standards maintained by the National Institute of Standards and Technology in Washington, D.C. and Boulder, CO. Completed record of all work performed is maintained by the Brunton Outdoor Group and is available for inspection upon request.

This unit has been calibrated to Lietz TM10E serial number 30937 traceable to N.B.S. Number 738227675 this 16<sup>TH</sup> Day May 20 13.

Description Pocket Transit

Purchase Order RA 256426895

Order Number SO-042272

Model Number F-5008

Serial Number 5080304492

Calibration Date May 16, 2013

Recalibration Date May 16, 2014

Signed Patricia K. Shuter

Quality Control Coordinator

**INQUEST**  
ENVIRONMENTAL INC.

3609 Mojave Ct., Ste E ♦ COLUMBIA, MO 65202  
(573) 474-8110 ♦ FAX: (573) 474-8371

May 30, 2014

Ms. Genevieve Bodnar  
Senior Environmental Engineer  
The Doe Run Company  
SEMO Division

RE: 2nd Quarter 2014 Lead/PM10 Samplers and Meteorological System  
Performance Audit Report.

Dear Ms. Bodnar,

Please find enclosed the worksheets detailing the Lead/PM10 sampler's multi-point and one-point flow verifications, and meteorological sensors accuracy checks that were recently performed on the Doe Run Park Hills Monitoring Network. A copy of the current certifications for the audit devices that was used has also been enclosed.

All of the verifications and checks were found to be within expected guidelines.

We had agreed that the wind monitor at the Big River site would be replaced since the existing unit was in need of repair. A new wind monitor was installed and its accuracy was verified to be correct.

After reviewing the enclosed information, please feel free to call with any comments or questions. Thank you for your business.

Sincerely,



John A. Kunkel  
Inquest Environmental, Inc.

## **PM10 Sampler Verifications**

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Big River	Intercept (Qa)	-0.00227
Sampler	#4 Primary PM10	Temperature	23.2 °C 296.4 °K
Flow Controller	P1019	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.80	1.177	28.50	53.23	0.930	1.135	-3.57	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.40	54.91	0.928	1.133	1.173	3.81	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.75	1.169	29.40	54.91	0.928	1.133	-3.08	± 4%
3.80	1.177	28.50	53.23	0.930	1.135	-3.57	± 4%
3.85	1.184	27.40	51.17	0.933	1.139	-3.80	± 4%
3.90	1.192	25.90	48.37	0.937	1.144	-4.03	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100



Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Big River	Intercept (Qa)	-0.00227
Sampler	#4 QA PM10	Temperature	23.2 °C 296.4 °K
Flow Controller	P2952	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.70	1.161	27.70	51.73	0.932	1.125	-3.10	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.10	54.35	0.929	1.121	1.156	2.30	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.60	1.145	28.40	53.04	0.930	1.122	-2.01	± 4%
3.65	1.153	28.00	52.29	0.931	1.123	-2.60	± 4%
3.70	1.161	27.70	51.73	0.932	1.125	-3.10	± 4%
3.75	1.169	27.00	50.43	0.934	1.127	-3.59	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (South)	Intercept (Qa)	-0.00227
Sampler	#1 PM10	Temperature	30.0 °C 303.2 °K
Flow Controller	P1500	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate	Acceptable
Manometer	Flow Rate	Manometer	Pressure	Press. Ratio	Flow Rate	Percent	Range
"H <sub>2</sub> O	m <sup>3</sup> /min	"H <sub>2</sub> O	(Pf)	(Po/Pa)	m <sup>3</sup> /min	Difference	
3.70	1.174	28.40	53.04	0.930	1.145	-2.47	± 7%

Sampler Operating Flow Rate						
Manometer	Pressure	Press. Ratio	Flow Rate	Corrected	Design %	Acceptable
"H <sub>2</sub> O	(Pf)	(Po/Pa)	m <sup>3</sup> /min	Flow Rate	Difference	Range
29.00	54.16	0.929	1.144	1.172	3.72	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate	Acceptable
Manometer	Flow Rate*	Manometer	Pressure	Press. Ratio	Flow Rate	Percent	Range
"H <sub>2</sub> O	m <sup>3</sup> /min	"H <sub>2</sub> O	(Pf)	(Po/Pa)	m <sup>3</sup> /min	Difference	
3.65	1.166	29.10	54.35	0.929	1.144	-1.89	± 4%
3.70	1.174	28.40	53.04	0.930	1.145	-2.47	± 4%
3.75	1.182	26.50	49.49	0.935	1.152	-2.54	± 4%
3.80	1.190	25.50	47.63	0.938	1.156	-2.86	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (School)	Intercept (Qa)	-0.00227
Sampler	#2 PM10	Temperature	27.0 °C 300.2 °K
Flow Controller	P6071	Station Pressure	30.04 "Hg 763.0 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.75	1.176	29.30	54.72	0.928	1.151	-2.13	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.20	54.54	0.929	1.152	1.176	4.07	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.70	1.168	30.00	56.03	0.927	1.150	-1.54	± 4%
3.75	1.176	29.30	54.72	0.928	1.151	-2.13	± 4%
3.80	1.184	28.00	52.29	0.931	1.154	-2.53	± 4%
3.85	1.191	26.70	49.87	0.935	1.159	-2.69	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

#### Calculations:

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (Mill St)	Intercept (Qa)	-0.00227
Sampler	#3 PM10	Temperature	29.0 °C 302.2 °K
Flow Controller	P1018	Station Pressure	30.03 "Hg 762.8 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.80	1.188	28.80	53.79	0.929	1.146	-3.54	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
28.70	53.60	0.930	1.147	1.188	5.13	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.75	1.180	29.50	55.10	0.928	1.145	-2.97	± 4%
3.80	1.188	28.80	53.79	0.929	1.146	-3.54	± 4%
3.85	1.195	25.80	48.19	0.937	1.156	-3.26	± 4%
3.90	1.203	22.80	42.58	0.944	1.165	-3.16	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\* ( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Rivermines (Quarry)	Intercept (Qa)	-0.00227
Sampler	#1 PM10	Temperature	26.4 °C 299.6 °K
Flow Controller	P4601	Station Pressure	29.98 "Hg 761.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.50	1.136	28.90	53.98	0.929	1.098	-3.35	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.10	54.35	0.929	1.098	1.135	0.44	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.40	1.120	29.50	55.10	0.928	1.097	-2.05	± 4%
3.50	1.136	28.90	53.98	0.929	1.098	-3.35	± 4%
3.55	1.144	27.30	50.99	0.933	1.102	-3.67	± 4%
3.60	1.152	26.10	48.75	0.936	1.106	-3.99	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

#### Calculations:

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Rivermines (Wood St)	Intercept (Qa)	-0.00227
Sampler	#2 PM10	Temperature	26.4 °C 299.6 °K
Flow Controller	P4507	Station Pressure	29.98 "Hg 761.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.45	1.128	28.30	52.85	0.931	1.120	-0.71	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.00	54.16	0.929	1.118	1.126	-0.35	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.40	1.120	29.50	55.10	0.928	1.117	-0.27	± 4%
3.45	1.128	28.30	52.85	0.931	1.120	-0.71	± 4%
3.50	1.136	27.40	51.17	0.933	1.123	-1.14	± 4%
3.55	1.144	26.50	49.49	0.935	1.125	-1.66	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Rivermines (Wtr Plnt)	Intercept (Qa)	-0.00227
Sampler	#3 PM10	Temperature	30.5 °C    303.7 °K
Flow Controller	P2951	Station Pressure	30.02 "Hg    762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.65	1.167	28.30	52.85	0.931	1.135	-2.74	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.40	54.91	0.928	1.131	1.162	2.83	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.60	1.159	29.60	55.28	0.928	1.131	-2.42	± 4%
3.65	1.167	28.30	52.85	0.931	1.135	-2.74	± 4%
3.70	1.175	27.40	51.17	0.933	1.137	-3.23	± 4%
3.75	1.183	26.00	48.56	0.936	1.138	-3.80	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Ozark Insulation	Intercept (Qa)	-0.00227
Sampler	#1 PM10	Temperature	30.0 °C    303.2 °K
Flow Controller	P2950	Station Pressure	29.98 "Hg    761.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.65	1.167	28.40	53.04	0.930	1.130	-3.17	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
28.00	52.29	0.931	1.131	1.167	3.27	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.60	1.159	29.50	55.10	0.928	1.128	-2.67	± 4%
3.65	1.167	28.40	53.04	0.930	1.130	-3.17	± 4%
3.70	1.175	27.00	50.43	0.934	1.135	-3.40	± 4%
3.75	1.183	26.10	48.75	0.936	1.138	-3.80	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100



Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Hanley Park	Intercept (Qa)	-0.00227
Sampler	#2 PM10	Temperature	30.5 °C    303.7 °K
Flow Controller	P2949	Station Pressure	30.00 "Hg    762.0 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.60	1.160	28.00	52.29	0.931	1.128	-2.76	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
29.30	54.72	0.928	1.125	1.156	2.30	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.50	1.143	29.40	54.91	0.928	1.125	-1.57	± 4%
3.60	1.160	28.00	52.29	0.931	1.128	-2.76	± 4%
3.65	1.168	27.20	50.80	0.933	1.131	-3.17	± 4%
3.70	1.176	26.40	49.31	0.935	1.133	-3.66	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	St Joe Park	Intercept (Qa)	-0.00227
Sampler	#4 PM10	Temperature	30.5 °C 303.7 °K
Flow Controller	P4353	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.50	1.143	29.00	54.16	0.929	1.120	-2.01	± 7%

Sampler Operating Flow Rate						
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Design % Difference	Acceptable Range
28.50	53.23	0.930	1.121	1.144	1.24	± 10%

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Flow Rate Percent Difference	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate* m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.45	1.135	30.60	57.15	0.925	1.116	-1.67	± 4%
3.50	1.143	29.00	54.16	0.929	1.120	-2.01	± 4%
3.60	1.159	28.10	52.48	0.931	1.122	-3.19	± 4%
3.65	1.167	27.40	51.17	0.933	1.125	-3.60	± 4%

\*At least 3 of 4 orifice flow rates must be between 1.13 ± 10% (1.02 and 1.24)

**Calculations:**

Pressure mmHg (Pf) - ("H<sub>2</sub>O/13.6) \* 25.4

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Flow Rate Percent Difference- (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Percent Difference)/100)

Design Percent Difference- (Corrected Flow Rate-1.13)/1.13\*100

## **Lead/TSP Sampler Verifications**

Date	May 13, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Big River	Intercept (Qa)	-0.00227
Sampler	#4 Primary TSP	Temperature	13.9 °C    287.1 °K
Flow Controller	P4557	Station Pressure	30.11 "Hg    764.8 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.90	1.171	20.90	39.05	0.949	1.222	<b>4.36</b>	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
20.80	38.86	0.949	1.222	<b>1.169</b>	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.80	1.156	24.20	45.21	0.941	1.211	<b>4.76</b>	± 5%
3.85	1.164	22.00	41.10	0.946	1.218	<b>4.64</b>	± 5%
3.90	1.171	20.90	39.05	0.949	1.222	<b>4.36</b>	± 5%
3.95	1.179	19.20	35.87	0.953	1.228	<b>4.16</b>	± 5%
4.00	1.186	17.00	31.76	0.958	1.234	<b>4.05</b>	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 13, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Big River #4	Intercept (Qa)	-0.00227
Sampler	QA TSP	Temperature	13.9 °C 287.1 °K
Flow Controller	P4558	Station Pressure	30.11 "Hg 764.8 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.05	1.194	20.10	37.55	0.951	1.220	2.18	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
20.20	37.74	0.951	1.220	1.193	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
3.90	1.171	22.90	42.78	0.944	1.211	3.42	± 5%
4.00	1.186	21.10	39.42	0.948	1.216	2.53	± 5%
4.05	1.194	20.10	37.55	0.951	1.220	2.18	± 5%
4.10	1.201	19.30	36.06	0.953	1.223	1.83	± 5%
4.20	1.215	18.40	34.38	0.955	1.226	0.91	± 5%

**Calculations:**Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (South)	Intercept (Qa)	-0.00227
Sampler	#1 TSP	Temperature	30.0 °C 303.2 °K
Flow Controller	P4559	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.50	1.295	26.80	50.07	0.934	1.237	-4.48	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
27.00	50.44	0.934	1.237	1.292	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.266	28.40	53.06	0.930	1.232	-2.69	± 5%
4.40	1.280	27.50	51.38	0.933	1.236	-3.44	± 5%
4.50	1.295	26.80	50.07	0.934	1.237	-4.48	± 5%
4.60	1.309	24.80	46.33	0.939	1.244	-4.97	± 5%
4.65	1.316	22.00	41.10	0.946	1.254	-4.71	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (School)	Intercept (Qa)	-0.00227
Sampler	#2 TSP	Temperature	27.0 °C 300.2 °K
Flow Controller	P6793	Station Pressure	30.04 "Hg 763.0 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.40	1.273	26.60	49.70	0.935	1.216	-4.48	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
26.00	48.58	0.936	1.217	1.271	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.259	28.70	53.62	0.930	1.209	-3.97	± 5%
4.35	1.266	27.80	51.94	0.932	1.212	-4.27	± 5%
4.40	1.273	26.60	49.70	0.935	1.216	-4.48	± 5%
4.45	1.281	24.60	45.96	0.940	1.223	-4.53	± 5%
4.55	1.295	22.10	41.29	0.946	1.231	-4.94	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Leadwood (Mill St)	Intercept (Qa)	-0.00227
Sampler	#3 TSP	Temperature	29.0 °C 302.2 °K
Flow Controller	P4476	Station Pressure	30.03 "Hg 762.8 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.50	1.292	23.40	43.72	0.943	1.233	-4.57	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
23.90	44.65	0.941	1.230	1.286	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.35	1.271	26.80	50.07	0.934	1.221	-3.93	± 5%
4.40	1.278	24.60	45.96	0.940	1.229	-3.83	± 5%
4.50	1.292	23.40	43.72	0.943	1.233	-4.57	± 5%
4.55	1.299	21.70	40.54	0.947	1.239	-4.62	± 5%
4.60	1.307	19.20	35.87	0.953	1.247	-4.59	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)



Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Rivermines (Quarry)	Intercept (Qa)	-0.00227
Sampler	#1 TSP	Temperature	26.4 °C 299.6 °K
Flow Controller	P2940	Station Pressure	29.98 "Hg 761.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.259	27.20	50.82	0.933	1.216	-3.42	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
27.00	50.44	0.934	1.218	1.260	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.20	1.244	28.70	53.62	0.930	1.212	-2.57	± 5%
4.25	1.252	28.10	52.50	0.931	1.213	-3.12	± 5%
4.30	1.259	27.20	50.82	0.933	1.216	-3.42	± 5%
4.35	1.266	25.80	48.20	0.937	1.222	-3.48	± 5%
4.45	1.281	24.10	45.03	0.941	1.227	-4.22	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H2O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date <u>May 20, 2014</u>	Auditor <u>John Kunkel</u>
Operator <u>The Doe Run Company</u>	Transfer Orifice <u>1882</u>
Location <u>Park Hills Network</u>	Slope (Qa) <u>1.03497</u>
Station <u>Rivermines Wood St</u>	Intercept (Qa) <u>-0.00227</u>
Sampler <u>#2 TSP</u>	Temperature <u>26.4</u> °C <u>299.6</u> °K
Flow Controller <u>P2941</u>	Station Pressure <u>29.98</u> "Hg <u>761.5</u> mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.20	1.244	26.50	49.51	0.935	1.221	-1.85	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
26.20	48.95	0.936	1.222	1.245	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.00	1.214	28.60	53.43	0.930	1.214	0.00	± 5%
4.10	1.229	27.90	52.13	0.932	1.217	-0.98	± 5%
4.20	1.244	26.50	49.51	0.935	1.221	-1.85	± 5%
4.25	1.252	25.00	46.71	0.939	1.226	-2.08	± 5%
4.35	1.266	23.90	44.65	0.941	1.229	-2.92	± 5%

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**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H2O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Rivermines Wtr Plnt	Intercept (Qa)	-0.00227
Sampler	#3 TSP	Temperature	30.5 °C 303.7 °K
Flow Controller	P4475	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.267	26.50	49.51	0.935	1.221	-3.63	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
26.20	48.95	0.936	1.222	1.266	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.25	1.259	28.10	52.50	0.931	1.216	-3.42	± 5%
4.35	1.274	27.40	51.19	0.933	1.218	-4.40	± 5%
4.30	1.267	26.50	49.51	0.935	1.221	-3.63	± 5%
4.40	1.281	25.10	46.89	0.939	1.227	-4.22	± 5%
4.45	1.289	23.00	42.97	0.944	1.233	-4.34	± 5%

**Calculations:**Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date <u>May 20, 2014</u>	Auditor <u>John Kunkel</u>
Operator <u>The Doe Run Company</u>	Transfer Orifice <u>1882</u>
Location <u>Park Hills Network</u>	Slope (Qa) <u>1.03497</u>
Station <u>Ozark Insulation</u>	Intercept (Qa) <u>-0.00227</u>
Sampler <u>#1 TSP</u>	Temperature <u>30.0</u> °C <u>303.2</u> °K
Flow Controller <u>P2939</u>	Station Pressure <u>29.98</u> "Hg <u>761.5</u> mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.40	1.281	25.50	47.64	0.937	1.232	-3.83	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
25.10	46.89	0.938	1.233	1.280	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.25	1.259	27.50	51.38	0.933	1.226	-2.62	± 5%
4.30	1.266	26.80	50.07	0.934	1.228	-3.00	± 5%
4.40	1.281	25.50	47.64	0.937	1.232	-3.83	± 5%
4.50	1.296	24.00	44.84	0.941	1.237	-4.55	± 5%
4.55	1.303	22.90	42.78	0.944	1.241	-4.76	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	Hanley Park (Crane St.)	Intercept (Qa)	-0.00227
Sampler	#2 TSP	Temperature	30.5 °C 303.7 °K
Flow Controller	P4474	Station Pressure	30.00 "Hg 762.0 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.267	26.60	49.70	0.935	1.215	-4.10	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
26.50	49.51	0.935	1.215	1.265	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.10	1.237	28.70	53.62	0.930	1.208	-2.34	± 5%
4.20	1.252	27.50	51.38	0.933	1.212	-3.19	± 5%
4.30	1.267	26.60	49.70	0.935	1.215	-4.10	± 5%
4.35	1.274	24.80	46.33	0.939	1.220	-4.24	± 5%
4.40	1.282	23.00	42.97	0.944	1.227	-4.29	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

Date	May 20, 2014	Auditor	John Kunkel
Operator	The Doe Run Company	Transfer Orifice	1882
Location	Park Hills Network	Slope (Qa)	1.03497
Station	St Joe Park	Intercept (Qa)	-0.00227
Sampler	#4 TSP	Temperature	30.5 °C 303.7 °K
Flow Controller	P6792	Station Pressure	30.02 "Hg 762.5 mmHg

Flow Rate Audit							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.30	1.267	25.70	48.02	0.937	1.227	-3.16	± 7%

Sampler Operating Flow Rate					
Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min	Corrected Flow Rate	Acceptable Range
26.20	48.95	0.936	1.226	1.265	1.10 - 1.70

Multi-point Flow Rate Verification							
Transfer Orifice		Sampler				Calibration Error %	Acceptable Range
Manometer "H <sub>2</sub> O	Flow Rate m <sup>3</sup> /min	Manometer "H <sub>2</sub> O	Pressure (Pf)	Press. Ratio (Po/Pa)	Flow Rate m <sup>3</sup> /min		
4.20	1.252	28.30	52.87	0.931	1.219	-2.64	± 5%
4.25	1.259	27.70	51.75	0.932	1.220	-3.10	± 5%
4.30	1.267	25.70	48.02	0.937	1.227	-3.16	± 5%
4.40	1.281	24.80	46.33	0.939	1.230	-3.98	± 5%
4.50	1.296	23.60	44.09	0.942	1.234	-4.78	± 5%

**Calculations:**

 Pressure mmHg (Pf) - "H<sub>2</sub>O \* 1.86832

Pressure Ratio (Po/Pa) - 1-Pf/Pa

 Orifice Flow Rate (Qa) - 1/Slope\*( Sqrt("H<sub>2</sub>O\*( Ta/Pa))-Intercept)

Sampler Flow Rate (Qa) - Taken from the look-up tables

Calibration Error - (Sampler Flow-Orifice Flow)/Orifice Flow\*100

Corrected Flow Rate - Operating Flow\*((100-Calibration Error)/100)

## Calibration Orifice Certification Worksheet



TISCH ENVIRONMENTAL, INC.  
 145 SOUTH MIAMI AVE  
 VILLAGE OF CLEVELAND, OH  
 44115  
 513.467.9000  
 877.263.7610 TOLL FREE  
 513.467.9009 FAX

# ORIFICE TRANSFER STANDARD CERTIFICATION WORKSHEET TE-5028A

Date - Jan 09, 2014 Rootmeter S/N 0438320 Ta (K) - 292  
 Operator Tisch Orifice I.D. - 1882 Pa (mm) - 759.46

PLATE OR VDC #	VOLUME START (m3)	VOLUME STOP (m3)	DIFF VOLUME (m3)	DIFF TIME (min)	METER DIFF Hg (mm)	ORFICE DIFF H2O (in.)
1	NA	NA	1.00	1.3530	4.1	1.50
2	NA	NA	1.00	1.0430	6.8	2.50
3	NA	NA	1.00	0.9510	8.1	3.00
4	NA	NA	1.00	0.8790	9.5	3.50
5	NA	NA	1.00	0.6660	16.3	6.00

## DATA TABULATION

Vstd	(x axis) Qstd	(y axis)	Va	(x axis) Qa	(y axis)
1.0143	0.7496	1.2368	0.9945	0.7350	0.7594
1.0106	0.9690	1.5967	0.9910	0.9501	0.9804
1.0089	1.0608	1.7491	0.9893	1.0402	1.0740
1.0070	1.1456	1.8893	0.9874	1.1233	1.1600
0.9978	1.4983	2.4736	0.9784	1.4691	1.5188
Qstd slope (m) = 1.65282			Qa slope (m) = 1.03497		
intercept (b) = -0.00370			intercept (b) = -0.00227		
coefficient (r) = 0.99999			coefficient (r) = 0.99999		
y axis = SQRT[H2O(Pa/760)(298/Ta)]			y axis = SQRT[H2O(Ta/Pa)]		

## CALCULATIONS

Vstd = Diff. Vol [(Pa-Diff. Hg)/760] (298/Ta)  
 Qstd = Vstd/Time

Va = Diff Vol [(Pa-Diff Hg)/Pa]  
 Qa = Va/Time

For subsequent flow rate calculations:

Qstd = 1/m{[SQRT(H2O(Pa/760)(298/Ta))] - b}  
 Qa = 1/m{[SQRT H2O(Ta/Pa)] - b}



## **Meteorological Sensor's Accuracy Checks**

# Inquest Environmental, Inc.

## Wind Direction Sensor Performance Audit

Operator The Doe Run Co  
 Location Big River  
 Station Name Meteorological System  
 Technician J. Kunkel/R Jones

Date 05/13/2014  
 Start Time 09:00  
 Stop Time 12:30

Sensor Mfg RM Young  
 Sensor Model Wind Monitor AQ  
 Serial Number 128618  
 Sensor Height 10.0 Meters

Station Declination 0.0 Deg  
 Measured Angle 180.0 Deg  
 Corrected Angle 180.0 Deg  
 Alignment Error 0.0 Deg

Vane Angle	Data Logger	Results	
		Difference ± 3 Deg Limit	Total Error ± 5 Deg Limit
0/360	0.3	0.3	0.3
90	91.0	1.0	1.0
180	179.0	-1.0	-1.0
270	270.5	0.5	0.5

Average Difference (Degrees)	0.2
Average Total Error (Degrees)	0.2

Audit Device	Wind Vane Alignment	Direction
Type	Pocket Transit	Vane Angle Fixture
Mfg.	Brunton	R.M. Young
Model	5008	18212
Serial No.	5080304492	None

Comments: Wind direction was verified by determining the orientation of the sensor in respect to True North. This was measured using a tri-pod mounted transit aligned along the length of the sensor while locked from rotating. A magnetic declination of -0 degrees was used to determine True North. The linearity of the sensor was determined by aligning the sensor to an indexed test fixture provided by the manufacturer. The four cardinal directions were verified using the fixture. No adjustments were made to the sensor.

# Inquest Environmental, Inc.

## Wind Speed Audit

Operator The Doe Run Co  
 Location Big River  
 Station Name Meteorological System  
 Auditor(s) J Kunkel/M. Kunkel

Date 05/13/2014  
 Start Time 09:00  
 Stop Time 12:30

Sensor Mfg RM Young  
 Sensor Model Wind Monitor AQ  
 Serial Number 128618  
 Sensor Height 10.0 Meters

Audit Standard		DAS Response		Limit
RPM	MPH	MPH	Difference	MPH
Zero	0.00	0.00	0.00	0.45
500	5.70	5.70	0.00	0.74
1000	11.50	11.50	0.00	1.03
1500	17.20	17.20	0.00	1.31
2000	22.90	22.90	0.00	1.60
3000	34.40	34.50	0.10	2.17
6000	68.70	68.70	0.00	3.89
Average			0.02	

± (0.45 MPH + 5%)

Audit Device	Anemometer Drive
Type	Variable Speed
Mfg.	R.M. Young
Model	18801
Serial No.	CAO1631

Comments: Wind speed was verified using a variable speed anemometer drive. The propellor was removed from the sensor and the drive was connected using a flexible connector. The sensor was then rotated in the appropriate direction at several different speeds. Sensor responses were taken from the data logger. No adjustments were made to the sensor.

# Inquest Environmental, Inc.

## Barometric Pressure Sensor Performance Audit

Operator The Doe Run Co  
 Location Big River  
 Station Name Meteorological System  
 Technician J Kunkel/M Kunkel

Date 05/13/2014  
 Start Time 09:00  
 Stop Time 12:30

Sensor Mfg Setra  
 Sensor Model 276  
 Serial Number 2626447

Audit Device	Data Logger Response	
	BP	Difference
mm HG	mm HG	mm HG
744.10	746.30	2.20

Note: Limit is +/- 7.5 mm HG.

Audit Device	
Type	Digital Barometer
Mfg.	AIR
Model	AIR-HB-1A
Serial No.	6G3745

Comments: The barometric pressure is verified by co-locating the sensor with a certified digital barometer. The verification was conducted at one level after allowing the sensor and calibration device ample time to stabilize.  
The sensor error was determined by comparing the sensor's data logger response to the display on the certified digital barometer. No adjustments were made to the sensor.

# Inquest Environmental, Inc.

## Temperature Sensor Performance Audit

Operator The Doe Run Co  
Location Big River  
Station Name Meteorological System  
Technician J Kunkel/M Kunkel

Date 05/13/2014  
Start Time 09:00  
Stop Time 12:30

### Sensor Information

Sensor Mfg Climatronics  
Sensor Model NA  
Serial Number NA  
Sensor Height 2 meters

Audit Device °C	Sensor	
	Data Logger °C	Difference °C
1.00	0.90	-0.10
16.20	16.30	0.10
45.30	45.10	-0.20
Average		-0.07

Note: The limit for each point is +/- 0.5 °C

Audit Device	
Type	Digital Thermometer
Mfg.	Control Company
Model	15-077-8
Serial No.	21357521

Comments: The temperature is verified by co-locating the sensor with a certified  
digital thermometer. The verification is conducted at three levels using  
two water baths (iced and hot water) and the ambient temperature.  
The sensor error was determined by comparing the sensor's data logger  
response to the display on the certified digital thermometer. No  
adjustments were made to the sensor.

# Inquest Environmental, Inc.

## Precipitation Gauge Performance Audit

Operator The Doe Run Co  
Location Big River  
Station Name Meteorological System  
Technician J Kunkel/M Kunkel

Date 05/13/2014  
Start Time 09:00  
Stop Time 12:30

Sensor Mfg Texas Electronics  
Sensor Model TR525I  
Serial Number 36611-805  
Diameter (inches) 6.00

Audit Device	Data Logger Response	
	Gauge Tips	Difference %
Known Tips		
98.00	93.00	-5.10

Note: Limit is +/- 10%.

Audit Device	
Type	Graduated Beaker
Mfg.	Texas Instruments
Model	FC-525
Serial No.	NA

Comments: The precipitation gauge output was verified using a field calibration kit supplied by the manufacturer. The kit consists of a graduated beaker and a calibration funnel using a precision orifice at the water outlet. Water was measured in the beaker and poured into the funnel while mounted on the gauge. The amount of precipitation recorded by the data logger was then compared to the known amount of water passing through the funnel. 100 tips equals one inch of rainfall. The gauge was cleaned and no adjustments were made.

## **Meteorological Audit Devices Certifications**



**CALIBRATION PROCEDURE**  
**18801/18810 ANEMOMETER DRIVE**

**DWG: CP18801(A)**

REV: C101107

PAGE: 2 of 3

BY: TJT

DATE: 10/11/07

CHK: JC

W.C. GAS-12

**CERTIFICATE OF CALIBRATION AND TESTING**

MODEL: **18801** (Comprised of Models 18820 Control Unit & 18830 Motor Assembly)

SERIAL NUMBER: CA01631

R. M. Young Company certifies that the above equipment was inspected and calibrated prior to shipment in accordance with established manufacturing and testing procedures. Standards established by R.M. Young Company for calibrating the measuring and test equipment used in controlling product quality are traceable to the National Institute of Standards and Technology.

Nominal Motor Rpm	Output Frequency Hz (1)	Calculated Rpm (2)	Indicated Rpm (3)
600	320	600	600
1200	640	1200	1200
2400	1280	2400	2400
4200	2240	4200	4200
6,000	3200	6000	6000
8,100	4320	8100	8100
9,900	5280	9900	9900
<input checked="" type="checkbox"/> Clockwise and Counterclockwise rotation verified			

- (1) Measured at the optical encoder output.  
(2) Frequency output produces 32 pulses per revolution of motor shaft.  
(3) Indicated on the Control Unit LCD display.

\* Indicates out of tolerance

☒ No Calibration Adjustments Required

☐ As Found

☐ As Left

Traceable frequency meter used in calibration Model: DP5740 SN: 4683

Date of inspection 15 Nov 2013

Inspection Interval One Year

Tested By EC





Calibration complies with ISO/IEC  
17025, ANSI/NCSL Z540-1, and 9001



Cert. No.: 4000-5654260

### Traceable® Certificate of Calibration for Digital Thermometer

Cust ID: Inquest Environmental Inc., 3609 Mojave Ct. Suite E, Attn. Mitchell Kunkel, Columbia, MO 65202 U.S.A. (RMA:983601)

#### Instrument Identification:

Model Numbers: 15-077-8, FB50266, 245BY S/N: 21357521 Manufacturer: Control Company

Model: 15-077-7 S/N: 72415694

#### Standards/Equipment:

Description	Serial Number	Due Date	NIST Traceable Reference
Temperature Calibration Bath TC-179	A45240		
Thermistor Module	A17118	2/13/14	1000332071
Temperature Probe	128	2/20/14	6-B4829-30-1
Temperature Calibration Bath TC-218	A73332		
Thermistor Module	A27129	10/25/14	1000346002
Temperature Probe	5202	11/30/14	15-B15PW-1-1
Temperature Calibration Bath TC-275	B16388		
Digital Thermometer	B16815	8/12/14	1000341967
PRT Temperature Probe	02022	8/14/15	B3812004

#### Certificate Information:

Technician: 68

Procedure: CAL-06

Cal Date: 1/17/14

Cal Due: 1/17/15

Test Conditions: 24.5°C 32.0 %RH 1026 mBar

#### Calibration Data:

Unit(s)	Nominal	As Found	In Tol	Nominal	As Left	In Tol	Min	Max	±U	TUR
°C	0.000	0.006	Y	0.000	0.000	Y	-0.050	0.050	0.013	3.8:1
°C	25.003	25.003	Y	25.003	24.999	Y	24.953	25.053	0.023	2.2:1
°C	60.000	59.988	Y	60.000	60.002	Y	59.950	60.050	0.014	3.6:1
°C	99.998	99.961	Y	99.998	100.000	Y	99.948	100.048	0.018	2.8:1

**This Instrument was calibrated using Instruments Traceable to National Institute of Standards and Technology.**

A Test Uncertainty Ratio of at least 4:1 is maintained unless otherwise stated and is calculated using the expanded measurement uncertainty. Uncertainty evaluation includes the instrument under test and is calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement" (GUM). The uncertainty represents an expanded uncertainty using a coverage factor k=2 to approximate a 95% confidence level. In tolerance conditions are based on test results falling within specified limits with no reduction by the uncertainty of the measurement. The results contained herein relate only to the item calibrated. This certificate shall not be reproduced except in full, without written approval of Control Company.

Nominal=Standard's Reading; As Left=Instrument's Reading; In Tol=In Tolerance; Min/Max=Acceptance Range; ±U=Expanded Measurement Uncertainty; TUR=Test Uncertainty Ratio; Accuracy=±(Max-Min)/2; Min = As Left Nominal(Rounded) - Tolerance; Max = As Left Nominal(Rounded) + Tolerance; Date=MM/DD/YY

*Nicol Rodriguez*  
Nicol Rodriguez, Quality Manager

*Aaron Judice*  
Aaron Judice, Technical Manager

#### Maintaining Accuracy:

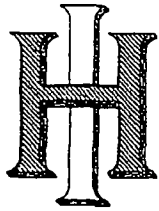
In our opinion once calibrated your Digital Thermometer should maintain its accuracy. There is no exact way to determine how long calibration will be maintained. Digital Thermometers change little, if any at all, but can be affected by aging, temperature, shock, and contamination.

#### Recalibration:

For factory calibration and re-certification traceable to National Institute of Standards and Technology contact Control Company.

CONTROL COMPANY 4455 Rex Road Friendswood, TX 77546 USA  
Phone 281 482-1714 Fax 281 482-9448 service@control3.com www.control3.com

Control Company is an ISO 17025:2005 Calibration Laboratory Accredited by (A2LA) American Association for Laboratory Accreditation, Certificate No. 1750.01.  
Control Company is ISO 9001:2008 Quality Certified by (DNV) Det Norske Veritas, Certificate No. CERT-01805-2006-AQ-HOU-RvA.  
International Laboratory Accreditation Cooperation (ILAC) - Multilateral Recognition Arrangement (MRA).



# HASS INSTRUMENT CORPORATION

6711 OLD BRANCH AVENUE • CAMP SPRINGS, MD 20748-6990 • (301) 449-5454 • FAX (301) 449-5455

## CALIBRATION REPORT

BAROMETER/ALTIMETER  
AIR Model AIR-HB-1A  
Serial No. 6G3745

TEST POINT	TEST PRESSURE	DIGITAL READOUT	READOUT ERROR	CORRECTION REQUIRED
1	930.00	931.9	+1.9	-1.9
2	970.00	971.9	+1.9	-1.9
3	1010.00	1012.0	+2.0	-2.0
4	1050.00	1051.9	+1.9	-1.9
5	1018.01	1019.9	+1.9	-1.9

### NOTES:

1. All data are in Millibars (hPa) and were taken at 75 F (24 C).
2. To correct the Digital Readout of the instrument, either algebraically add the CORRECTION REQUIRED to, or algebraically subtract the READOUT ERROR from, the readout shown on the instrument.
3. The TEST PRESSURE was generated using Type A-1 Barometer S/N 3327, and was approached in an increasing-pressure direction.
4. The TEST PRESSURE for TEST POINT 5 was ambient atmospheric pressure.
5. The BAROMETER/ALTIMETER was horizontal during the calibration.
6. The LCD screen of the BAROMETER/ALTIMETER has some trash in the center of the display, but it does not interfere with the readout.
7. Although the Digital Readout of the instrument can be adjusted to incorporate the average CORRECTION REQUIRED, this has not been done.

Calibration Date: 5 February 2014

By: Bernard I. Hass

Bernard I. Hass

(SEAL)

# BRUNTON OUTDOOR GROUP

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## CERTIFICATE OF CALIBRATION

### Equipment Owner

Name: Environmental Atten: Mitchell Kunkel  
Address: 3609 Mojave Court Ste E  
Columbia, MO 65202

Calibration traceable to the National Institute of Standards and Technology in accordance with MIL-STD-45662A has been accomplished on the instrument listed below by comparison with standards maintained by the Brunton Outdoor Group. The accuracy and stability of all standards maintained by the Brunton Outdoor Group are traceable to national standards maintained by the National Institute of Standards and Technology in Washington, D.C. and Boulder, CO. Completed record of all work performed is maintained by the Brunton Outdoor Group and is available for inspection upon request.

This unit has been calibrated to Lietz TM10E serial number 30937 traceable to N.B.S. Number 738227675 this 16<sup>TH</sup> Day May 20 13.

Description Pocket Transit

Purchase Order RA 256426895

Order Number SO-042272

Model Number F-5008

Serial Number 5080304492

Calibration Date May 16, 2013

Recalibration Date May 16, 2014

Signed Patricia K. Shuter

Quality Control Coordinator